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DISCUSSION OF CONSUMPTIVE USE IN MUNICIPAL AND INDUSTRIAL AREAS

(Published in November, 1951)

By Robert H. Born, and Meyer Kramsky

IRRIGATION AND DRAINAGE DIVISION

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DISCUSSION

ROBERT H. BORN,[4] J. M. ASCE.—Information obtained in the Raymond Basin court reference has been widely accepted as an important contribution to the fund of knowledge concerning municipal water use. The writer concurs in Mr. Gleason's conclusion that further experimental work is necessary to establish, more definitely, the units of water use for various types of urban culture.

As a research project in connection with the current California State-Wide Water Resources Investigation under the direction of the State Water Resources Board, the Division of Water Resources has amassed additional water-use data in the Los Angeles and Vernon industrial areas. Conducted in the fall of 1949 and spring of 1950, the study had as its objective, the determination of units of water usage applicable to large industrial sectors in the Los Angeles metropolitan area. The area surveyed covered approximately 2,500 acres of land devoted entirely to industrial purposes wherein were located representatives of the following industries: Steel mills, breweries and wineries, soft drink manufacturers, canneries (processed food), chemical plants, paint and varnish manufacturers, rubber products manufacturers, paper mills, meat packers, tanneries, wool pullers, rendering plants, ceramic industries (pottery, china, and glass), ice and cold storage plants, fabricated metal products manufacturers, warehouses, and railroad marshalling yards.

The total water delivered to the area was determined from metered records of the cities of Los Angeles and Vernon and from records and estimates of water pumped from private wells. It was determined that approximately 27,000 acre-ft of water was applied during the fiscal year, 1949–1950, to the 2,500 acres of industrial lands, giving an applied water-use factor of approximately 10.8 acre-ft per acre per year.

TABLE 2.—SELECTED INDUSTRIAL WATER-USE FACTORS

Industry	Number of plants surveyed	Water-Use Factor, In Acre-Feet per Acre per Year	
		Average	Range
(1)	(2)	(3)	(4)
Paper mills	four	162.8	11.9 to 247.5
Meat packing	eight	54.5	16.2 to 97.3
Ice and cold storage	two	16.1	14.9 to 17.2
Chemical	two	12.9	2.2 to 109.1

Among the interesting facts revealed in this survey, it was discerned that adequate information concerning quantities of water consumptively used (that is, the water lost through evaporation from steam lines, boiler blow-off, and cooling towers) is not generally available due, for the most part, to the lack of sufficient and reliable waste measurements.

It was also noted that a tremendous variation exists in the water use between the several types of industries as well as between industries of the

NOTE.—This paper by George B. Gleason was published in November, 1951, as *Proceedings-Separate No. 99*. The numbering of footnotes and tables in this Separate is a continuation of the consecutive numbering used in the original paper.

[4] Asst. Hydr. Engr., Div. of Water Resources, California Dept. of Public Works, Los Angeles, Calif.

same general category. An indication of the quantities of water required by a few of the heavy water users in the area surveyed is given in Table 2.

The lack of correlation between industrial water use and plant area is readily apparent in Table 2. The effect of this variation is even more pronounced when these water-use data are compared on a percentage basis. Within the four paper mills surveyed, for example, the applied water-use factors varied from 7% to 150% of the average of the four plants. Within the total industrial area surveyed, applied water-use factors varied from 12% to 2,300% of the average factor for the entire area.

The significant variation in industrial water use leads to the conclusion that water consumption expressed as a quantity of use per unit of area may not be a valid indicator of industrial water requirements except where the factor has been obtained from a survey of a large area comprising many types of industries. With so wide a variation in unit values of water applied, there must also be significant variation in the quantities consumed per acre.

The results of the aforementioned survey have stimulated the writer to investigate further a more logical basis on which to determine water requirements of individual industries. Preliminary information obtained thus far indicates that, in the meat packing industry for instance, water-use factors expressed as a quantity of water per unit of plant production (gallons per 1,000 lb of kill) are the most consistent of all.

MEYER KRAMSKY,[5] A.M. ASCE.—The author has presented a comprehensive analysis of consumptive use in the western unit of the Raymond Basin Area of Southern California. That area is part of metropolitan Los Angeles, and is predominantly suburban residential in character, with heavy industry practically nonexistent. The City of Pasadena occupies most of the area.

It is assumed that consumptive use in the Raymond Basin Area is confined to natural evapo-transpiration losses from the various surfaces included therein. Weighted average unit consumptive-use factors are determined for the several land-use classifications based upon relative proportions of the various types of vegetative cover and bare surface included within each classification. Total consumptive use is obtained by applying the appropriate unit factor to the total acreage devoted to that particular land use.

This procedure is entirely valid for regions where native vegetation, agriculture, and municipal residential use predominate, but is not necessarily applicable where an appreciable part of the area under consideration is devoted to heavy industry. There is no particular relationship between area occupied and water consumed in manufacturing processes, such as exists for the other land-use categories, and the infinite variety of industrial water usage renders fallacious any generalized conclusions drawn from limited studies.

Industrial Process Consumptive Use in West Coast Basin.—As part of its investigation as referee in an adjudication of water rights,[6] the Division of Water Resources, Department of Public Works of the State of California, con-

[5] Senior Hydr. Engr., California Div. of Water Resources, Los Angeles, Calif.

[6] California Water Service Co., et al, vs. City of Compton, et al, No. 506806 in the Superior Court of the State of California, in and for the County of Los Angeles, October 24, 1945.

ducted an extensive study of water use and disposal in the West Coast Basin of Los Angeles County. This area encompasses 101,000 acres, in which extensive industrial installations are located with oil refineries predominating. More than 40% of all applied waters (excluding rainfall) in the West Coast Basin are used for industrial purposes.

The large proportion of water used by industry, and the preponderance of water evaporation processes involved in the refining of oil, indicate that industrial processing accounts for a major part of the consumptive use of water in the West Coast Basin. This use is in addition to, and entirely unrelated to, the normal evapo-transpiration losses from the ground surface.

Surface losses in the West Coast Basin were analyzed and evaluated by the conventional methods demonstrated by the author. Consumptive use by industrial processing, however, was measured by comparison of industrial water usage with resulting sewage effluent, based on the assumption that industrial waters are disposed of by either consumptive use or discharge as industrial

TABLE 2.—INDUSTRIAL PROCESS CONSUMPTIVE USE IN ACRE-FEET, WEST COAST BASIN

Year	Sewered Area								Consumptive use-ratio (%)	Entire Basin	
	Number of dwelling units	Unit water requirements	Domestic water delivered	Domestic waste	Total sewage	Industrial waste	Applied industrial water	Industrial process consumptive use		Applied industrial water	Industrial process consumptive use
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1932–33	70,400	0.237	16,700	10,000	15,800	5,800	14,300	8,500	59	22,700	13,500
1933–34	71,200	0.237	16,800	10,100	14,600	4,500	14,300	9,800	68	22,600	15,500
1934–35	75,400	0.237	17,900	10,700	14,700	4,000	12,900	8,900	69	20,700	14,300
1935–36	83,100	0.237	19,100	11,500	16,200	4,700	18,100	13,400	74	26,700	19,800
1936–37	85,000	0.237	20,100	12,100	14,600	2,500	18,400	15,900	86	27,400	23,700
1937–38	89,100	0.237	21,000	12,600	16,100	3,500	18,200	14,700	81	25,800	20,800
1938–39	92,600	0.237	21,900	13,100	16,800	3,700	19,700	16,000	81	29,200	23,700
1939–40	98,000	0.237	23,200	13,900	18,600	4,700	18,500	13,800	75	28,900	21,600
1940–41	110,000	0.224	22,900	13,700	19,800	6,100	21,200	15,100	71	32,200	22,900
1941–42	116,200	0.241	27,900	16,700	22,900	6,200	21,800	15,600	72	33,500	24,000
1942–43	122,300	0.268	32,600	19,600	25,200	5,600	24,000	18,400	77	42,400	32,500
1943–44	135,100	0.260	34,900	20,900	31,000	10,100	31,200	21,100	68	53,900	36,400
1944–45	139,700	0.277	38,500	23,100	33,400	10,300	39,200	28,900	74	67,300	49,600
1945–46	145,800	0.320	46,400	27,800	36,200	8,400	32,900	24,500	74	56,400	42,000
1946–47	151,900	0.296	44,800	26,900	36,200	9,300	28,900	19,600	68	53,400	36,200
1947–48	161,700	0.299	48,100	28,900	38,400	9,500	38,900	29,400	76	57,500	43,500
1948–49	169,600	0.298	50,300	30,200	40,900	10,700	44,600	33,900	76	62,900	47,800
1949–50	182,400	0.283	51,300	30,800	48,100	17,300	48,600	31,300	64	67,900	43,700

wastes. It was assumed that the industrial water used for purposes other than industrial processing and incidental sanitary use was negligible. Under these assumptions, the difference between applied industrial water and industrial waste is a measure of consumptive use by industrial processing.

Applied waters in the basin were segregated into three broad classifications: Municipal, industrial, and irrigational. Municipal use was estimated by applying the average water demand per dwelling unit, as determined from detailed studies of representative water distribution systems, to the total number of dwelling units in the basin, taken from census reports and studies of the Regional Planning Commission of Los Angeles County. The water used for

irrigation was ascertained by examination of the records of the various water producers and distributors. The remaining applied water was assumed to represent industrial use (Col. 11, Table 2).

The volume of industrial waste was evaluated as the difference between total sewage and domestic waste, as presented in Table 2. A count of the total number of sewage connections in the basin was converted to an equivalent number of dwelling units in the sewered area. Domestic waste was estimated as 60% of the water supply to these dwelling units, based on the relationship between water and sewage in representative residential areas. The remaining sewage was considered to be industrial waste from the sewered area.

Industrial waste in the basin is disposed of through the several sewerage systems or by discharge into Dominguez Channel, a surface water course. Since industrial waste determination has been limited to that portion discharged into the sewerage system, it was necessary to determine the corresponding volume of industrial water served to the sewered area. This was accomplished by deducting the water supply of industrial installations tributary to Dominguez Channel from the total applied industrial water.

In accordance with the basic assumption employed herein, industrial process consumptive use in the sewered area was computed as the difference between applied industrial water and industrial waste as previously evaluated. The large volumes of water evaporated and the extensive recirculation of water effected by the industries are reflected in the extremely high consumptive-use ratio, averaging more than 70% of the applied water. This ratio, as determined for the sewered area, was considered representative of the entire basin and was used to determine the total annual consumptive use by industrial processing, as shown in Table 2.

Since consumptive use by industrial processing is not amenable to analysis and determination on an acreage basis, the techniques presented by the author are not particularly adaptable to this problem. A reasonable estimate of industrial process consumptive use can be obtained through comparison of the volume of applied industrial water with the resulting industrial waste. Evaluation of these items, however, is usually laborious and involved, and should not be undertaken unless the cultural development of the area under consideration includes large industrial establishments whose consumptive use is an appreciable item of water disposal.

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